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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/817,354	04/02/2004	Oomman K. Varghese	PSU-100A	3287

28304 7590 07/08/2005

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ART UNIT	**PAPER NUMBER**
1753	

DATE MAILED: 07/08/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Office Action Summary	Application No.	Applicant(s)	
	10/817,354	VARGHESE ET AL.	
	Examiner	Art Unit	
	Edna Wong	1753	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *10 June 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-11,13,14 and 23-39* is/are pending in the application.

4a) Of the above claim(s) *1-11,13 and 14* is/are withdrawn from consideration.

5)☒ Claim(s) *30* is/are allowed.

6)☒ Claim(s) *23-29 and 31-39* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *April 21, 2005*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

Election/Restrictions

Applicant's election with traverse of Group II, claims **23-39**, in the reply filed on June 10, 2005 is acknowledged. The traversal is on the ground(s) that the claims do not have patentably distinct features and should be lumped together as obvious structural alternatives. This is not found persuasive because the search required for the method claims is not required for the device claims, restriction for examination purposes as indicated is proper.

The requirement is still deemed proper and is therefore made FINAL.

Specification

Applicant is reminded of the proper language and format for an abstract of the disclosure.

The abstract should be in narrative form and generally limited to a single paragraph on a separate sheet within the range of 50 to 150 words. It is important that the abstract not exceed 150 words in length since the space provided for the abstract on the computer tape used by the printer is limited. The form and legal phraseology often used in patent claims, such as "means" and "said," should be avoided. The abstract should describe the disclosure sufficiently to assist readers in deciding whether there is a need for consulting the full patent text for details.

The language should be clear and concise and should not repeat information given in the title. It should avoid using phrases which can be implied, such as, "The disclosure concerns," "The disclosure defined by this invention," "The disclosure describes," etc.

The abstract of the disclosure is objected to because the abstract exceeds 150 words in length. Correction is required. See MPEP § 608.01(b).

Claim Objections

Claims **24-25, 28, 32 and 37-38** are objected to because of the following informalities:

Claim 24

line 4, the word “a” (second occurrence) should be amended to the word -- the --.

line 5, the word “a” (second occurrence) should be amended to the word -- the --.

Claim 25

line 8, the word “a” should be amended to the word -- the --.

Claim 28

line 9, the word “a” should be amended to the word -- the --.

Claim 32

line 6, the word “a” (second occurrence) should be amended to the word -- the --.

line 7, the word “a” should be amended to the word -- the --.

Claim 34

line 5, the word “a” should be amended to the word -- the --.

Claim 37

line 4, the word "a" (second occurrence) should be amended to the word -- the --.

line 5, the word "a" should be amended to the word -- the --.

Claim 38

line 2, the word "a" should be amended to the word -- the --.

Appropriate correction is required.

Claim Rejections - 35 USC § 112

• The following is a quotation of the first paragraph of 35 U.S.C. 112:

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

I. Claims **31, 33 and 36** are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention.

Claim 31

lines 2-3, the limitation of "(a) wherein said titania nanotubes are formed to have

a length greater than 600 nm" is new matter.

Claim 33

line 3, the limitation of "(a) forming an array of titania nanotubes having a length greater than 600 nm" is new matter.

Claim 36

line 3, the limitation of "(a) forming an array of titania nanotubes having a length greater than 600 nm" is new matter.

Applicants' specification does not describe this in their specification.

• The following is a quotation of the second paragraph of 35 U.S.C. 112:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

II. Claims **24-25, 28-29, 31-35, 37 and 39** are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 24

lines 2-5, it appears that "exposing an outwardly-directed surface of said titanium layer to an acidic electrolyte solution comprising a fluoride compound and an acid at a voltage from a range from 100 mV to 40 V, for a selected time-period within a range of 1

minute to 24 hours" is further limiting the anodizing recited in claim 23, line 4. However, it is unclear if it is.

If it is, then it is suggested that the words "wherein said step of forming said array" be amended to the words -- wherein said anodizing --.

lines 2-3, "an outwardly-directed surface of said titanium layer" lacks antecedent basis. According to claim 23, lines 3-4, an array of nanotubes open at an outwardly-directed end.

Claim 25

lines 2-3, it appears that "exposing an outwardly-directed surface of said foil layer to an acidic electrolyte solution comprising a fluoride compound" is further limiting the anodizing recited in claim 23, line 4. However, it is unclear if it is.

If it is, then it is suggested that the words "wherein said step of forming said array" be amended to the words -- wherein said anodizing --.

Claim 28

lines 3-5, it appears that "exposing an outwardly-directed surface of said doped titanium foil layer to an acidic electrolyte solution comprising a fluoride compound" is further limiting the anodizing recited in claim 26, line 4. However, it is unclear if it is.

If it is, then it is suggested that the words "said step of forming said array" be

amended to the words -- said anodizing --.

Claim 29

lines 5-6, "said integral support member" lacks antecedent basis.

Claim 32

lines 4-7, it appears that "exposing an outwardly-directed surface of said first titanium layer to an acidic electrolyte solution comprising a fluoride compound and an acid at a voltage from a range from 6 mV to 25 V, for a selected time-period within a range of 1 minute to 24 hours" is further limiting the anodizing recited in claim 29, line 4. However, it is unclear if it is.

If it is, then it is suggested that the words "wherein said step of forming said array" be amended to the words -- wherein said anodizing --.

Claim 33

lines 5-6, "said integral support member" lacks antecedent basis.

Claim 35

lines 4-5, it appears that "an electrically insulative substrate layer" is the same as that recited in claim 33, line 6. However it is unclear if it is.

<u>Claim 37</u>

lines 2-5, it appears that "exposing an outwardly-directed surface of said first titanium layer to an acidic electrolyte solution comprising a fluoride compound and an acid at a voltage from a range from 6 mV to 25 V, for a selected time-period within a range of 1 minute to 24 hours" is further limiting the anodizing recited in claim 36, line 4. However, it is unclear if it is.

If it is, then it is suggested that the words "wherein said step of forming said array" be amended to the words -- wherein said anodizing --.

<u>Claim 39</u>

lines 3-4, it appears that "exposing an outwardly-directed surface of said foil layer to an acidic electrolyte solution comprising a fluoride compound" is further limiting the anodizing recited in claim 36, line 4. However, it is unclear if it is.

If it is, then it is suggested that the words "said step of forming said array" be amended to the words -- wherein said anodizing --.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

I. Claim **23** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Zuttel et al.** ("Thermodynamic Aspects of the Interaction of Hydrogen With Pd Clusters", *Applied Surface Science*, Vols. 162-163 (2000), pp. 571-575).

JP '106 teaches a method of producing an electrical resistive device for sensing hydrogen gas, the method comprising the steps of:

(a) forming an array of titania nanotubes **12** open at an outwardly-directed end (= pillar-shaped TiO_2 crystal is perpendicularly prolonged from the substrate) by anodizing (= anodic oxidation) at least a portion of a titanium layer (= metal Ti) [page 2, [0011]];

(b) depositing palladium **14** atop said array of titania nanotubes by performing a deposition process selected from the group consisting of: sputtering, evaporation using thermal energy, E-beam evaporation, ion assisted deposition, ion plating, electrodeposition, screen printing, chemical vapor deposition, molecular beam epitaxy (MBE), electroless deposition, and laser ablation (= vacuum deposition, sputtering, etc.) [page 2, [0008]]; and

(c) said array of titania nanotubes being mechanically supported by an integral support member **30** (= a p-type silicon substrate) [page 2, [0010]].

The step of forming said array comprises exposing an outwardly-directed surface of said titanium layer to an acidic electrolyte solution comprising an acid (= sulfuric acid) at a voltage for a selected time-period within a range of 1 minute to 24 hours (= 30 minutes) [page 3, [0016]).

Prior to said anodizing, depositing said titanium layer atop said integral support

member **30**, which comprises an electrically insulative substrate layer (= a p-type silicon substrate) [page 2, [0010]].

The method of JP '106 differs from the instant invention because JP '106 does not disclose depositing a plurality of palladium clusters.

Zuttel teaches that Pd clusters reversibly absorb and desorb hydrogen. The miscibility gap narrows with decreasing cluster size and therefore an increased hydrogen solubility was found for Pd clusters as compared to bulk Pd (page 571, Abstract).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the deposition of palladium described by JP '106 to depositing a plurality of palladium clusters as taught by Zuttel because Pd clusters would have reversibly absorbed and desorbed hydrogen and would have increased hydrogen solubility as compared to bulk Pd.

II. Claim **24** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Zuttel et al.** ("Thermodynamic Aspects of the Interaction of Hydrogen With Pd Clusters", *Applied Surface Science*, Vols. 162-163 (2000), pp. 571-575) as applied to claim 23 above, and further in view of **Quinn** (US Patent No. 3,180,807) and **Lu et al.** (US Patent Application Publication No. 2005/0103639 A1).

JP '106 and Zuttel describe a method having the limitations recited in claim 23 of the instant application, as explained above in I.

The method described by JP '106 and Zuttel differ from the instant invention because they do not disclose the following:

a. Wherein said step of forming said array comprises exposing said outwardly-directed surface of said titanium layer to an acidic electrolyte solution comprising a fluoride compound at a voltage selected from a range from 100 mV to 40V.

b. Wherein depositing said titanium layer atop said integral support member is by performing a deposition process selected from the group consisting of: sputtering, evaporation using thermal energy, E-beam evaporation, ion assisted deposition, ion plating. electrodeposition, screen printing, chemical vapor deposition, molecular beam epitaxy (MBE), electroless deposition, and laser ablation.

Quinn teaches that exposing a titanium layer to an acidic electrolyte solution comprising a fluoride compound (= sodium fluoride) [col. 5, lines 43-46] produces high resistivity films of remarkably high stability (col. 2, lines 31-58). The voltage source is adjustable up to 100 volts (col. 4, lines 71-72).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the acidic electrolyte solution described by JP '106 to an acidic electrolyte solution comprising a fluoride compound as taught by Quinn

because film resistivity of high stability would have been obtained.

The voltage is a result-effective variable and one skilled in the art has the skill to calculate the voltage that would determine the success of the desired reaction to occur, absent evidence to the contrary. MPEP § 2141.03 and § 2144.05(b).

Lu teaches sputtering a titanium film on a silicon wafer (pages 1-2, [0017] and [0018]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the metal Ti described by JP '106 by depositing said titanium layer by sputtering as taught by Lu because sputtering a titanium film on a silicon wafer is conventional in the art.

III. Claim **25** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Zuttel et al.** ("Thermodynamic Aspects of the Interaction of Hydrogen With Pd Clusters", *Applied Surface Science*, Vols. 162-163 (2000), pp. 571-575) as applied to claim 23 above, and further in view of **Quinn** (US Patent No. 3,180,807) and **EP 1,254,870 A2** ('870).

JP '106 and Zuttel describe a method having the limitations recited in claim 23 of the instant application, as explained above in **I**.

JP '106 also teaches wherein said titanium foil layer comprises a titanium foil layer **10**, leaving a substrate layer comprised of a portion of said titanium foil layer that

is not anodized, said integral support member comprising said substrate layer (Figs. 1 and 2).

The method described by JP '106 and Zuttel differ from the instant invention because they do not disclose the following:

a. Wherein said step of forming said array comprises exposing said outwardly-directed surface of said titanium layer to an acidic electrolyte solution comprising a fluoride compound.

b. Exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen to remove al least a portion of a contaminant if present on said titania nanotubes; said contaminant selected from the group consisting of: liquid crude petroleum, pathogens, fungi, and proteins.

Quinn teaches that exposing a titanium layer to an acidic electrolyte solution comprising a fluoride compound (= sodium fluoride) [col. 5, lines 43-46] produces high resistivity films of remarkably high stability (col. 2, lines 31-58).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the acidic electrolyte solution described by JP '106 to an acidic electrolyte solution comprising a fluoride compound as taught by Quinn because film resistivity of high stability would have been obtained.

EP '870 teaches that a hole-electron pair can be generated in sunlight and can react in humid air to form hydroxyl and peroxy radicals on the surface of the semiconductor. The radicals oxidize organic grime on the surface. Titanium dioxide may be deposited on to substrates to form a transparent coating with photocatalytic self-cleaning properties (page 1, [0002] and [0003]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen as taught by EP '870 because when titanium dioxide is illuminated by sunlight, a hole-electron pair would be generated and would have reacted in humid air to form hydroxyl and peroxy radicals on the surface of the titanium dioxide wherein the radicals would have oxidized organic grime on the surface.

IV. Claim **26** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Zuttel et al.** ("Thermodynamic Aspects of the Interaction of Hydrogen With Pd Clusters", *Applied Surface Science*, Vols. 162-163 (2000), pp. 571-575) and **Welsch et al.** (US Patent No. 6,914,769 B2).

JP '106 and Zuttel describe a method having the limitations recited in the instant application, as explained above in **I**.

JP '106 also teaches wherein said titanium layer comprises a titanium foil layer

10, leaving a substrate layer comprised of a portion of said titanium foil layer that is not anodized, said integral support member comprising said substrate layer (Figs. 1 and 2).

The method described by JP '106 and Zuttel differ from the instant invention because they do not disclose wherein the titanium layer comprises a dopant in an amount less than 1% by mass.

Welsch teaches that doping a titanium film with Zr, Ta, Be, Mg, Ca, Sr, Ba, Pb, Pd, Pt, Rh, V and Al significantly improves the properties of the dielectric (cols. 16-20, "The Dielectric Film"). For example, undoped TiO_2 has a dielectric constant of about 150 and a dielectric strength of about 7.5 MV/cm for anodically produced TiO_2. TiO_2 doped with a small amount of Ca (0.3%) has a dielectric constant of 900, with little or no decrease in dielectric strength as compared with an undoped TiO_2 (col. 18, lines 60-65).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the titanium layer described by JP '106 by incorporating a dopant in an amount less than 1% by mass as taught by Welsch because doping of the titanium film in an amount less than 1% by mass would have significantly improved the properties of the dielectric.

V. Claim **27** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Zuttel et al.** ("Thermodynamic Aspects of the Interaction of Hydrogen With Pd Clusters", *Applied Surface Science*, Vols. 162-163

(2000), pp. 571-575) and **Welsch et al.** (US Patent No. 6,914,769 B2) as applied to claim 26 above, and further in view of **Lu et al.** (US Patent Application Publication No. 2005/0103639 A1).

JP '106, Zuttel and Welsch describe a method having the limitations recited in claim 26 of the instant application, as explained above in **IV**.

The method described by JP '106, Zuttel and Welsch differ from the instant invention because they do not disclose the following:

a. Wherein said dopant comprises a material selected from the group consisting of: Pd, Pt, Sb, Sb_2O_3, In, Bi_2O_3, Ru, Nb, Ni, MgO, Au, Cr, Ag, Cu, N and C.

b. Wherein prior to said anodizing, depositing titanium and said dopant atop said integral support member by co-deposition process selected from the group consisting of: co-sputtering, co-evaporation using thermal energy, E-beam evaporation, ion assisted deposition, ion implantation, ion plating, chemical vapor deposition, laser ablations and thermal diffusion of said dopant into a deposited titanium matrix.

Welsch teaches doping a titanium film with Zr, Ta, Be, Mg, Ca, Sr, Ba, Pb, Pd, Pt, Rh, V and Al (cols. 16-20, "The Dielectric Film").

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the titanium layer described by JP '106 by doping it with a material selected from the group consisting of: Pd, Pt, Sb, Sb_2O_3, In, Bi_2O_3, Ru, Nb, Ni, MgO, Au, Cr, Ag, Cu, N and C as taught by Welsch because these materials

would have significantly improved the properties of the dielectric.

Welsch teaches that the dopant may be added either before, during, or after formation of the oxide film (col. 19, lines 6-7).

Lu teaches sputtering a titanium film on a silicon wafer (pages 1-2, [0017] and [0018]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the titanium layer described by JP '106 by depositing titanium and said dopant atop said integral support member by co-sputtering because adding the dopant either before, during, or after formation of the oxide film would have been functionally equivalent.

Sputtering a titanium film on a silicon wafer is conventional in the art as taught by Lu (pages 1-2, [0017] and [0018]).

VI. Claim **28** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Zuttel et al.** ("Thermodynamic Aspects of the Interaction of Hydrogen With Pd Clusters", *Applied Surface Science*, Vols. 162-163 (2000), pp. 571-575) and **Welsch et al.** (US Patent No. 6,914,769 B2) as applied to claim 26 above, and further in view of **EP 1,254,870 A2** ('870).

JP '106, Zuttel and Welsch describe a method having the limitations recited in claim 26 of the instant application, as explained above in **IV.**

The method described by JP '106, Zuttel and Welsch differ from the instant invention because they do not disclose exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen to remove al least a portion of a contaminant if present on said titania nanotubes; said contaminant selected from the group consisting of: liquid crude petroleum, pathogens, fungi, and proteins.

EP '870 teaches that a hole-electron pair can be generated in sunlight and can react in humid air to form hydroxyl and peroxy radicals on the surface of the semiconductor. The radicals oxidize organic grime on the surface. Titanium dioxide may be deposited on to substrates to form a transparent coating with photocatalytic self-cleaning properties (page 1, [0002] and [0003]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen as taught by EP '870 because when titanium dioxide is illuminated by sunlight, a hole-electron pair would be generated and would have reacted in humid air to form hydroxyl and peroxy radicals on the surface of the titanium dioxide wherein the radicals would have oxidized organic grime on the surface.

VII. Claim **33** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Varghese et al.** ("Crystallization and High-Temperature Structural Stability of Titanium Oxide Nanotube Arrays", *J. Mater. Res.*, Vol. 18, No. 1, January 2003, pp. 156-165) and **Lu et al.** (US Patent Application Publication No. 2005/0103639 A1).

JP '106 teaches a method of producing an electrical resistive device, the method comprising the steps of:

(a) forming an array of titania nanotubes **12** having a length and open at an outwardly-directed end (= pillar-shaped TiO_2 crystal is perpendicularly prolonged from the substrate) by anodizing (= anodic oxidation) at least a portion of a titanium layer (= metal Ti) [page 2, [0011]]; and

(b) prior to anodizing, depositing said titanium layer atop said integral support member **30**, which comprises an electrically insulative substrate layer (= a p-type silicon substrate) [page 2, [0010]].

The electrical resistive device so produced is adapted for sensing hydrogen gas (abstract).

The method described by JP '106 differs from the instant invention because JP '106 does not disclose the following:

a. Wherein the titania nanotubes have a length greater than 600 nm.

b. Wherein depositing said titanium layer atop said integral support member

is by performing a deposition process selected from the group consisting of: sputtering, evaporation using thermal energy, E-beam evaporation, ion assisted deposition, ion plating. electrodeposition, screen printing, chemical vapor deposition, molecular beam epitaxy (MBE), electroless deposition, and laser ablation.

c. After said anodizing, heat treating said array of titania nanotubes in the presence of oxygen.

Varghese teaches that using a simple anodization technique, nanotubes of inner diameters in the range approximately 20-90 nm and lengths 200-500 nm depending on the anodization voltage for an electrolyte concentration of 0.5 vol% hydrofluoric acid in water (page 156, right column, lines 3-12).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the titania nanotubes described by JP '106 by forming titania nanotubes having a length greater than 600 nm because this is well within the skill of the artisan dependent upon the intended use of the array, particularly to the environment to which the array will encounter, which would be most suited for the application of the array, absent evidence to the contrary.

Furthermore, the length of the titania nanotubes is a result-effective variable and one skilled in the art has the skill to calculate the length that would determine the success of the desired reaction to occur, e.g., the anodization voltage, absent evidence to the contrary. MPEP § 2141.03 and § 2144.05(b).

Lu teaches sputtering a titanium film on a silicon wafer (pages 1-2, [0017] and [0018]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the metal Ti described by JP '106 by depositing said titanium layer by sputtering as taught by Lu because sputtering a titanium film on a silicon wafer is conventional in the art.

Varghese teaches that anatase crystallites formed inside the tube walls are transformed completely to rutile at about 620°C in dry environments and 570°C in humid argon. No discernible changes in the dimensions of the tubes were found when the heat treatment was performed in oxygen (page 156, abstract). Rutile is mostly used in the area of dielectrics and high-temperature oxygen gas sensors (page 157, left column, lines 1-3).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by heat treating said array of titania nanotubes in the presence of oxygen as taught by Varghese because the anatase crystallites formed inside the tube walls would have been transformed completely to rutile.

VIII. Claim **34** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Varghese et al.** ("Crystallization and High-

Temperature Structural Stability of Titanium Oxide Nanotube Arrays", *J. Mater. Res.*, Vol. 18, No. 1, January 2003, pp. 156-165) and **Lu et al.** (US Patent Application Publication No. 2005/0103639 A1) as applied to claim 33 above, and further in view of **EP 1,254,870 A2** ('870).

JP '106, Varghese and Lu describe a method having the limitations recited in claim 33 of the instant application, as explained above in **VII.**

The method described by JP '106, Varghese and Lu differ from the instant invention because they do not disclose exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen to remove al least a portion of a contaminant if present on said titania nanotubes; said contaminant selected from the group consisting of: liquid crude petroleum, pathogens, fungi, and proteins.

EP '870 teaches that a hole-electron pair can be generated in sunlight and can react in humid air to form hydroxyl and peroxy radicals on the surface of the semiconductor. The radicals oxidize organic grime on the surface. Titanium dioxide may be deposited on to substrates to form a transparent coating with photocatalytic self-cleaning properties (page 1, [0002] and [0003]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies

from visible to ultraviolet in the presence of oxygen as taught by EP '870 because when titanium dioxide is illuminated by sunlight, a hole-electron pair would be generated and would have reacted in humid air to form hydroxyl and peroxy radicals on the surface of the titanium dioxide wherein the radicals would have oxidized organic grime on the surface as taught by EP '870.

IX. Claim **35** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Varghese et al.** ("Crystallization and High-Temperature Structural Stability of Titanium Oxide Nanotube Arrays", *J. Mater. Res.*, Vol. 18, No. 1, January 2003, pp. 156-165) and **Lu et al.** (US Patent Application Publication No. 2005/0103639 A1) as applied to claim 33 above, and further in view of **Zuttel et al.** ("Thermodynamic Aspects of the Interaction of Hydrogen With Pd Clusters", *Applied Surface Science*, Vols. 162-163 (2000), pp. 571-575).

JP '106, Varghese and Lu describe a method having the limitations recited in claim 33 of the instant application, as explained above in **VII.**

The method of JP '106 Varghese and Lu differ from the instant invention because they does not disclose the following:

a. Wherein said integral support member comprises a metal layer atop an electrically insulative substrate layer such that said step of depositing said titanium layer further comprises depositing said titanium layer atop said metal layer having been deposited atop said electrically insulative substrate layer.

b. Depositing a plurality of palladium clusters.

JP '106 teaches a silicon substrate.

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by depositing a metal layer atop said electrically insulative substrate layer because it is conventional in the art to deposit a seed layer on the silicon wafer to provide electrical conductivity to the electrically insulative substrate layer for an electrochemical deposition.

Zuttel teaches that Pd clusters reversibly absorb and desorb hydrogen. The miscibility gap narrows with decreasing cluster size and therefore an increased hydrogen solubility was found for Pd clusters as compared to bulk Pd (page 571, Abstract).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the deposition of palladium described by JP '106 to depositing a plurality of palladium clusters as taught by Zuttel because Pd clusters would have reversibly absorbed and desorbed hydrogen and would have increased hydrogen solubility as compared to bulk Pd.

X. Claim **36** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Varghese et al.** ("Crystallization and High-

Temperature Structural Stability of Titanium Oxide Nanotube Arrays", *J. Mater. Res.*, Vol. 18, No. 1, January 2003, pp. 156-165).

JP '106 teaches a method of producing an electrical resistive device, the method comprising the steps of:

(a) forming an array of titania nanotubes **12** having a length and open at an outwardly-directed end (= pillar-shaped TiO_2 crystal is perpendicularly prolonged from the substrate) by anodizing (= anodic oxidation) at least a portion of a titanium layer (= metal Ti) [page 2, [0011]]; and

(b) said array of titania nanotubes being mechanically supported by an integral support member **30** (page 2, [0010]).

The step of forming said array comprises exposing an outwardly-directed surface of said titanium layer to an acidic electrolyte solution comprising an acid (= sulfuric acid) at a voltage for a selected time-period within a range of 1 minute to 24 hours (= 30 minutes) [page 3, [0016]).

Prior to said anodizing, depositing said titanium layer atop said integral support member **30**, which comprises an electrically insulative substrate layer (= a p-type silicon substrate) [page 2, [0010]].

The method described by JP '106 differs from the instant invention because they do not disclose the following:

a. Wherein the titania nanotubes have a length greater than 600 nm.

b. After said anodizing, heat treating said array of titania nanotubes in the presence of oxygen.

Varghese teaches that using a simple anodization technique, nanotubes of inner diameters in the range approximately 20-90 nm and lengths 200-500 nm depending on the anodization voltage for an electrolyte concentration of 0.5 vol% hydrofluoric acid in water (page 156, right column, lines 3-12).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the titania nanotubes described by JP '106 by forming titania nanotubes having a length greater than 600 nm because this is well within the skill of the artisan dependent upon the intended use of the array, particularly to the environment to which the array will encounter, which would be most suited for the application of the array, absent evidence to the contrary.

Furthermore, the length of the titania nanotubes is a result-effective variable and one skilled in the art has the skill to calculate the length that would determine the success of the desired reaction to occur, e.g., anodization voltage, absent evidence to the contrary. MPEP § 2141.03 and § 2144.05(b).

Varghese teaches that anatase crystallites formed inside the tube walls are transformed completely to rutile at about 620°C in dry environments and 570°C in humid argon. No discernible changes in the dimensions of the tubes were found when the heat

treatment was performed in oxygen (page 156, abstract). Rutile is mostly used in the area of dielectrics and high-temperature oxygen gas sensors (page 157, left column, lines 1-3).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by heat treating said array of titania nanotubes in the presence of oxygen as taught by Varghese because the anatase crystallites formed inside the tube walls would have been transformed completely to rutile.

XI. Claim **37** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Varghese et al.** ("Crystallization and High-Temperature Structural Stability of Titanium Oxide Nanotube Arrays", *J. Mater. Res.*, Vol. 18, No. 1, January 2003, pp. 156-165) as applied to claim 36 above, and further in view of **Quinn** (US Patent No. 3,180,807) and **Lu et al.** (US Patent Application Publication No. 2005/0103639 A1).

JP '106 and Varghese describe a method having the limitations recited in claim 36 of the instant application, as explained above in **X**.

The method described by JP '106 and Varghese differ from the instant invention because they do not disclose the following:

a. Wherein said step of forming said array comprises exposing said outwardly-directed surface of said titanium layer to an acidic electrolyte solution

comprising a fluoride compound at a voltage selected from a range from 6 mV to 25V.

b. Wherein depositing said titanium layer atop said integral support member is by performing a deposition process selected from the group consisting of: sputtering, evaporation using thermal energy, E-beam evaporation, ion assisted deposition, ion plating. electrodeposition, screen printing, chemical vapor deposition, molecular beam epitaxy (MBE), electroless deposition, and laser ablation.

Quinn teaches that exposing a titanium layer to an acidic electrolyte solution comprising a fluoride compound (= sodium fluoride) [col. 5, lines 43-46] produces high resistivity films of remarkably high stability (col. 2, lines 31-58). The voltage source is adjustable up to 100 volts (col. 4, lines 71-72).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the acidic electrolyte solution described by JP '106 to an acidic electrolyte solution comprising a fluoride compound as taught by Quinn because film resistivity of high stability would have been obtained.

The voltage is a result-effective variable and one skilled in the art has the skill to calculate the voltage that would determine the success of the desired reaction to occur, absent evidence to the contrary. MPEP § 2141.03 and § 2144.05(b).

Lu teaches sputtering a titanium film on a silicon wafer (pages 1-2, [0017] and [0018]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the metal Ti described by JP '106 by depositing said titanium layer by sputtering as taught by Lu because sputtering a titanium film on a silicon wafer is conventional in the art.

XII. Claim **38** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Varghese et al.** ("Crystallization and High-Temperature Structural Stability of Titanium Oxide Nanotube Arrays", *J. Mater. Res.*, Vol. 18, No. 1, January 2003, pp. 156-165) as applied to claim 36 above, and further in view of **EP 1,254,870 A2** ('870).

JP '106 and Varghese describe a method having the limitations recited in claim 36 of the instant application, as explained above in **X**.

The method described by JP '106 and Varghese differ from the instant invention because they do not disclose exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen to remove al least a portion of a contaminant if present on said titania nanotubes; said contaminant selected from the group consisting of: liquid crude petroleum, pathogens, fungi, and proteins.

EP '870 teaches that a hole-electron pair can be generated in sunlight and can react in humid air to form hydroxyl and peroxy radicals on the surface of the

semiconductor. The radicals oxidize organic grime on the surface. Titanium dioxide may be deposited on to substrates to form a transparent coating with photocatalytic self-cleaning properties (page 1, [0002] and [0003]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen as taught by EP '870 because when titanium dioxide is illuminated by sunlight, a hole-electron pair would be generated and would have reacted in humid air to form hydroxyl and peroxy radicals on the surface of the titanium dioxide wherein the radicals would have oxidized organic grime on the surface.

XIII. Claim **39** is rejected under 35 U.S.C. 103(a) as being unpatentable over **JP 2002-236106** ('106) in combination with **Varghese et al.** ("Crystallization and High-Temperature Structural Stability of Titanium Oxide Nanotube Arrays", *J. Mater. Res.*, Vol. 18, No. 1, January 2003, pp. 156-165) as applied to claim 36 above, and further in view of **Quinn** (US Patent No. 3,180,807) and **EP 1,254,870 A2** ('870).

JP '106 and Varghese describe a method having the limitations recited in claim 36 of the instant application, as explained above in **X**.

JP '106 also teaches wherein said titanium layer comprises a titanium foil layer **10**, leaving a substrate layer comprised of a portion of said titanium foil layer that is not

anodized, said integral support member comprising said substrate layer (Figs. 1 and 2).

The method described by JP '106 and Varghese differ from the instant invention because they do not disclose:

a. Wherein said step of forming said array comprises exposing said outwardly-directed surface of said titanium layer to an acidic electrolyte solution comprising a fluoride compound.

b. Exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen to remove al least a portion of a contaminant if present on said titania nanotubes

Quinn teaches that exposing a titanium layer to an acidic electrolyte solution comprising a fluoride compound (= sodium fluoride) [col. 5, lines 43-46] produces high resistivity films of remarkably high stability (col. 2, lines 31-58).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the acidic electrolyte solution described by JP '106 to an acidic electrolyte solution comprising a fluoride compound as taught by Quinn because film resistivity of high stability are obtained.

EP '870 teaches that a hole-electron pair can be generated in sunlight and can react in humid air to form hydroxyl and peroxy radicals on the surface of the semiconductor. The radicals oxidize organic grime on the surface. Titanium dioxide may

be deposited on to substrates to form a transparent coating with photocatalytic self-cleaning properties (page 1, [0002] and [0003]).

It would have been obvious to one having ordinary skill in the art at the time the invention was made to have modified the method described by JP '106 by exposing said array of titania nanotubes to radiant energy emitted within a range of frequencies from visible to ultraviolet in the presence of oxygen as taught by EP '870 because when titanium dioxide is illuminated by sunlight, a hole-electron pair would be generated and would have reacted in humid air to form hydroxyl and peroxy radicals on the surface of the titanium dioxide wherein the radicals would have oxidized organic grime on the surface.

Allowable Subject Matter

The following is a statement of reasons for the indication of allowable subject matter:

Claims **29, 31 and 32** defines over the prior art of record because the prior art does not teach or suggest a method for producing an electrical resistive device, the method comprising the steps of (a) forming, (b) depositing and (c) depositing as presently claimed, esp., the step of (c) after said step of depositing said first titanium layer and prior to said anodizing, depositing a second titanium layer, leaving a portion of said first titanium layer uncovered for said forming said array of titania nanotubes.

Claim **30** defines over the prior art of record because the prior art does not teach

or suggest a method for producing an electrical resistive device for sensing hydrogen gas, the method comprising the steps of (a) forming, (b) depositing, (c) depositing, (d) heat treating as presently claimed, esp., the step of (c) after said step of depositing said aluminum layer, depositing said titanium layer atop said aluminum layer.

The prior art does not contain any language that teaches or suggests the above. Therefore, a person skilled in the art would not have been motivated to adopt the above conditions, and a prima facie case of obviousness cannot be established.

Claims 29, 31 and 32 would be allowable if rewritten or amended to overcome the rejection(s) under 35 U.S.C. 112, 1st and/or 2nd paragraphs, set forth in this Office action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Edna Wong whose telephone number is (571) 272-1349. The examiner can normally be reached on Mon-Fri 7:30 am to 4:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam Nguyen can be reached on (571) 272-1342. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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EW
July 6, 2005